Value of Citizen Science Monitoring

Involving citizen scientists in the sea star wasting disease survey effort has greatly expanded our spatial and temporal coverage. Citizen science groups can collect sea star population data using the MARINe sampling methods described below for counting and measuring sea stars and assessing condition in terms of wasting disease. In order to ensure repeatability of sampling effort within a group and standardize methods among groups, some initial training is required. A researcher from the MARINe group should accompany each citizen science group in the field to assist with appropriate site selection and set-up of permanent plots (if appropriate), and train participants in sea star species identification, proper measurement techniques and disease category designation. Scanned copies of data sheets should be sent to Rani Gaddam (gaddam@ucsc.edu) or Melissa Miner (cmminer@ucsc.edu) to be entered into the MARINe database. Data will be incorporated into the Sea Star Wasting Disease Map to enable groups to track the occurrence of wasting disease on a local and coast-wide scale.

Survey Methods:

Because the cause of sea star wasting syndrome is not fully understood, reasonable precautions against potential spread via sampling gear should be taken. Brush or spray gear (particularly boots) with freshwater to remove trapped material and spray with a dilute bleach solution between use at different sites. Also, avoid touching or marking sea stars showing symptoms of wasting disease with lumber crayons; instead, mark rock adjacent to these individuals (see methods below). If sick stars are touched (sometimes necessary to assess tissue softness/health), sterilize hands before touching additional animals.

Selection of survey sites should be based on appropriateness in terms of 1) habitat type and 2) location in order to ensure good geographical representation. For all areas, sea stars should be counted within clearly defined areas (using one of the approaches described below). The following information should be recorded for ochre stars (*Pisaster ochraceus*), and where appropriate, mottled stars (*Evasterias troschelii*)**:** 1) species, 2) size to nearest 10 **mm** (**NOT cm**), 3) disease category (healthy, mildly diseased, severely diseased). For all other sea star species, record 1) species, and 2) disease category. If diseased individuals are encountered, representative photos of all disease categories recorded should be taken for archival purposes. Special care should be taken to search for juveniles (<30 mm), as these are important for capturing new recruitment to sites.

The protocols below were designed for sampling in the intertidal zone. Subtidal protocols are also available on our website (seastarwasting.org).

Required Gear (for both survey types)
GPS
Flashlights/Headlamps
Rulers
Lumber crayons (yellow)
Camera
Data sheet
Pencils
Sanitizer gel/wipes

Optional Gear (for permanent plots only)
Meter tapes or line
Rock drill
Drill bit
Stainless steel bolts or screws
Z-spar marine epoxy or anchors for screws
Site map (if site already established)
Compass (to help locate bolts)
Site photos

Permanent Plots

Use datasheet labeled "SEA STARS —Disease Categories" for this approach when >1 plot is established. For sites with just one permanent plot, and one species to be measured use datasheet labeled with appropriate species' name ("*Pisaster ochraceus*" or "*Evasterias troschelii*"). For sites with one permanent plot, where both *Pisaster ochraceus* and *Evasterias troschelii* are common, use datasheet labeled "SEA STARS (*Pisaster ochraceus* and *Evasterias troschelii*) —Permanent Plot"

The number and sizes of ochre stars (and mottled stars if common) are recorded within the same well-defined areas (plots), repeatedly over time. Examples of appropriate "plots" include pier pilings, isolated boulders, or irregularly-shaped plots marked by four or more "corner" bolts (or screws or epoxy plugs), one of which is marked with notches indicating plot number. The most important feature of a plot is that it can be easily relocated, and sampled in the same way, over time. Typically, 3 separate plots are established (ideally with no shared sides) in areas of high sea star density (preferably >20 individuals/plot for a total of > 60-100 animals per site). Where plot markers are used, they should be placed on conspicuous (i.e., higher) rock features to ease relocation efforts, thus plot boundaries may include habitat unsuitable for sea stars. For this reason, **irregular plots are not intended to provide densities for comparison between sites**. Instead, they were designed to provide temporal comparisons within a site. After distinct "plots" have been chosen or permanent plot markers have been installed, a site map should be drawn showing prominent features of the area (e.g. large boulders, tide pools), with distances and compass bearings between plots or permanent markers clearly labeled. Plots should also be photographed from various angles.

To survey a plot, once the tide is low enough, a meter tape (or line) is laid out around the irregular plot perimeter (for plots with marker bolts), and the entire area encompassed by the boundary tape or within the defined plot boundaries (e.g. entire boulder or pier piling) is searched carefully. It is helpful to have a flashlight or headlamp to search within crevices. Size (radius) and disease category are recorded for all *Pisaster ochraceus* (and *Evasterias troschelii*) present. A sea star is considered in the plot if any

portion of the individual occurs within plot boundaries. **The "radius" of each sea star is measured with a ruler from the center of the disc to the tip of the longest ray to the nearest 5 mm for animals < 10 mm and the nearest 10 mm for larger individuals** (Note: sizes are in **mm, NOT cm**)**.** Often sizes must be estimated because sea stars are wedged in tight spots with rays curved. Sea stars should never be "straightened" or removed from the rock.

If stars have fewer than the normal number of arms (5 for most species), but otherwise appear healthy, they should be recorded as "healthy". Notes should be made about arm regrowth.

Figure 1. Method used for measuring sea star "radius"

Special care should be taken to search for juveniles (<30 mm), as these are important for capturing new recruitment to sites. Juvenile stars typically occur in crevices, and can be difficult to see without a flashlight. Juveniles can be tricky to ID to species, and can be easily confused with the small, 6-armed star, *Leptasterias*. If juveniles cannot be identified with certainty, they should be recorded as "unidentified". See the photo guide and descriptions specific to juveniles for tips on how to distinguish species.

Species other than *Pisaster ochraceus* are counted, but not measured and disease condition (healthy, mildly diseased, severely diseased) should be noted (*Evasterias troschelii* should also be measured where common). To avoid duplicate counting, it is helpful to use yellow lumber crayons to mark the rock adjacent to sea stars after they have been measured.

Unusual observations should be recorded in the notes section at the bottom of the datasheet. Unusual observations include "abnormal" sea star behavior such as "twisting", and falling off rocks. Signs of potential recovery from wasting should also be recorded, such as arm regrowth and lesion healing.

If diseased individuals are encountered, representative photos of all disease categories recorded should be taken for archival purposes. The following photo naming approach should be used:

genus_species_diseasecategory_site_year_monthday_photographer
Genus name can be abbreviated to the 1st letter so an example photo name would be:
p_brevispinus_mild_hop_2013_1113_dsteller
For sea star photos where disease category is unknown, use "catu". For photos of unusual observations, include a brief descriptor in place of disease category (e.g. "p_giganteus_twisted_postpoint_2013_1228_miner").

Permanent Plots designated by GPS coordinates

Use datasheet labeled "SEA STARS—Non-Permanent Plots/Timed Searches" for this approach.

Where establishing permanent plots is not possible, or sea stars exist in too few numbers to monitor within replicated plots, large "plot" boundaries can be delineated by GPS coordinates, and timed searches can be done. To survey (around the time of low tide), mark plot boundaries by recording them as waypoints. It is helpful to use natural prominent features as boundaries, if possible, and photograph GPS waypoint locations to improve repeatability of surveys. Within the area delineated by GPS coordinates, search all appropriate sea star habitat (e.g., crevices and pools) along the mid-low intertidal zone. Count (all species) and measure (ochre stars and mottled stars only) all sea stars encountered (using methods described above for permanent plots), and designate appropriate disease category. Record search effort as # minutes spent searching by total number of samplers (e.g. 3 people for 20 min, for a total search effort of 60 min).

Pisaster ochraceus

Site:_____

Recorder:_____

Date:_____

Sampler(s):_____

Disease Categories: healthy, mild= lesion(s) on no more than 2 arms or 1 arm and body and/or deteriorating arm(s), severe= lesions on most of body and/or missing arms, or severe tissue deterioration/death

Size	Disease Category		
Radius (mm)	healthy	mild	severe
5			
10			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			
170			
180			
190			
200			

Other Sea Stars [total # under appropriate general disease category only, no sizes]

Species	Healthy	Mildly Diseased	Severely Diseased

Other Observations (e.g. arm regrowth, lesion healing, "abnormal" twisting, etc.):

Evasterias troschelii

Site:_____   Recorder:_____

Date:_____   Sampler(s):_____

Disease Categories: healthy, mild= lesion(s) on no more than 2 arms or 1 arm and body and/or deteriorating arm(s), severe= lesions on most of body and/or missing arms, or severe tissue deterioration/death

Size	Disease Category		
Radius (mm)	healthy	mild	severe
5			
10			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			
170			
180			
190			
200			

Other Sea Stars [total # under appropriate general disease category only, no sizes]

Species	Healthy	Mildly Diseased	Severely Diseased

Other Observations (e.g. arm regrowth, lesion healing, "abnormal" twisting, etc.):

SEA STARS (*Pisaster ochraceus* and *Evasterias troschelii*)—Permanent Plot

Site:_____   Date:_____   Recorder:_____   Sampler(s):_____

Disease Categories: healthy, mild= lesion(s) on no more than 2 arms or 1 arm and body and/or deteriorating arm(s), severe= lesions on most of body and/or missing arms, or severe tissue deterioration/death

Size	*Pisaster ochraceus*			*Evasterias troschelii*		
Radius (mm)	Healthy	Mild	Severe	Healthy	Mild	Severe
5						
10						
20						
30						
40						
50						
60						
70						
80						
90						
100						
110						
120						
130						
140						
150						
160						
170						
180						
190						
200						

Other Sea Stars (total # and disease category only, no sizes; use 3 "general" disease categories for species other than *P. ochraceus* and *E. troschelii*)

Species	Healthy	Mildly Diseased	Severely Diseased

Other Observations (e.g. arm regrowth, lesion healing, "abnormal" twisting, etc.):

PISASTER PLOTS

Site: _____ Date: _____ Sampler(s): _____ Recorder: _____

Disease Categories: healthy, mild= lesion(s) on no more than 2 arms or 1 arm and body and/or deteriorating arm(s), severe= lesions on most of body and/or missing arms, or severe tissue deterioration/death

Size	Plot 1			Plot 2			Plot 3		
Radius (mm)	healthy	mild	severe	healthy	mild	severe	healthy	mild	severe
5									
10									
20									
30									
40									
50									
60									
70									
80									
90									
100									
110									
120									
130									
140									
150									
Totals									

Other Sea Stars (Record species, total # and general disease category. **H**=healthy, **M**=mildly diseased, **S**=severely diseased.

Species	Plot 1	Plot 2	Plot 3	Notes

Timed Search: *Pisaster ochraceus / Evasterias troschelii* (circle one)

Site:_____   Recorder:_____   Start Time:_____

Date:_____   Sampler:_____   End Time: _____

Disease Categories: healthy, mild= lesion(s) on no more than 2 arms or 1 arm and body and/or deteriorating arm(s), severe= lesions on most of body and/or missing arms, or severe tissue deterioration/death

Size	Disease Category		
Radius (mm)	Healthy	Mild	Severe
5			
10			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			
170			
180			
190			
200			

Other Sea Stars [total # under appropriate general disease category only, no sizes]

Species	Healthy	Mildly Diseased	Severely Diseased

Other Observations (e.g. arm regrowth, lesion healing, "abnormal" twisting, etc.):

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Inspired Picture Photos
Last updated October 2, 2018

lesion(s) on 1 arm or body
Tissue degradation in some of
these photos may be the
result of multiple lesions
merging, but it is restricted to
a single arm, or single
location on the oral disk.

Photo: Melissa Miner

Photo: Melissa Miner

Photo: Melissa Miner

Photo: Melissa Miner

Photo: Melissa Miner

Photo: Melissa MIner

NOT a lesion (madreporite)
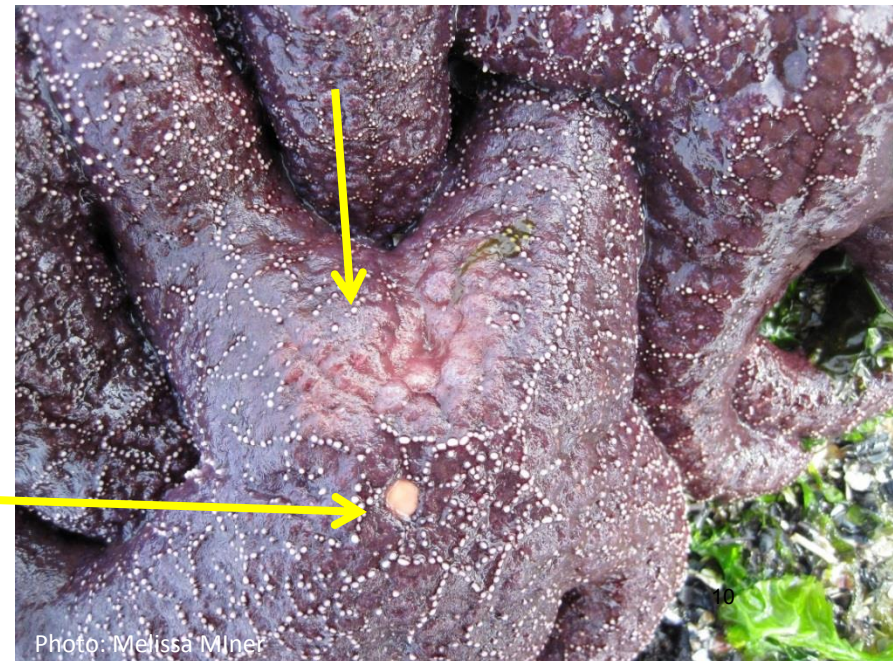
Photo: Melissa MIner

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lesions on 2 arms or 1 arm and body and/or deteriorating arm(s)

Photo: Melissa Miner
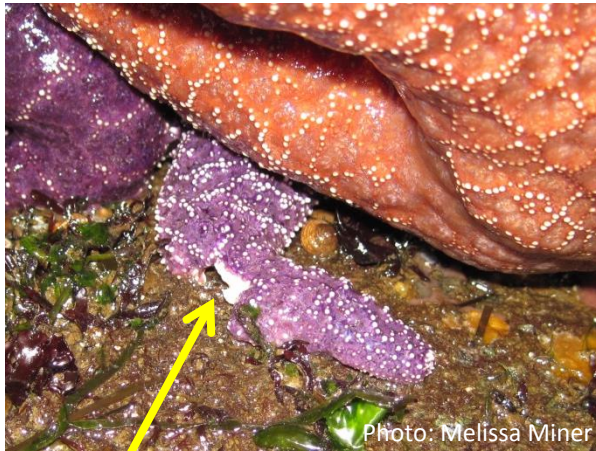
Arm starting to separate

Photo: Melissa Miner
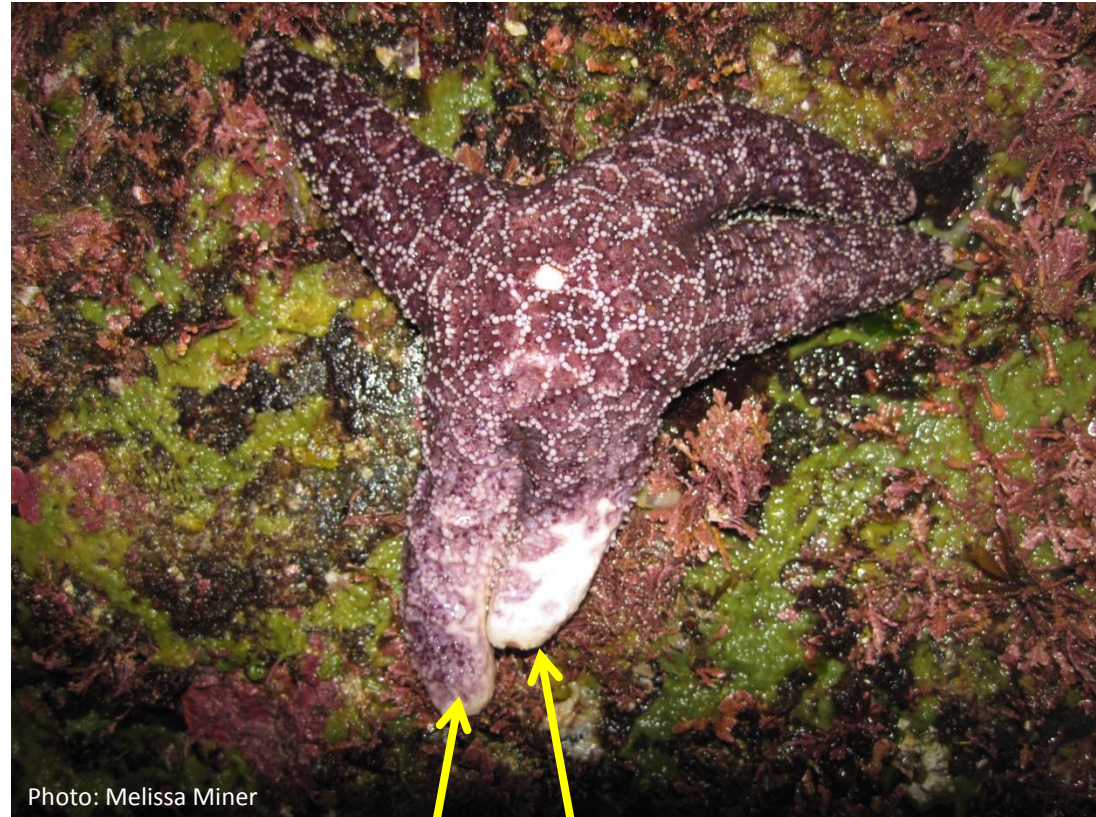
Tissue deteriorating on 2 arms

Severe (previously Category 3)

lesions on most of body and/or 1-2 missing arms

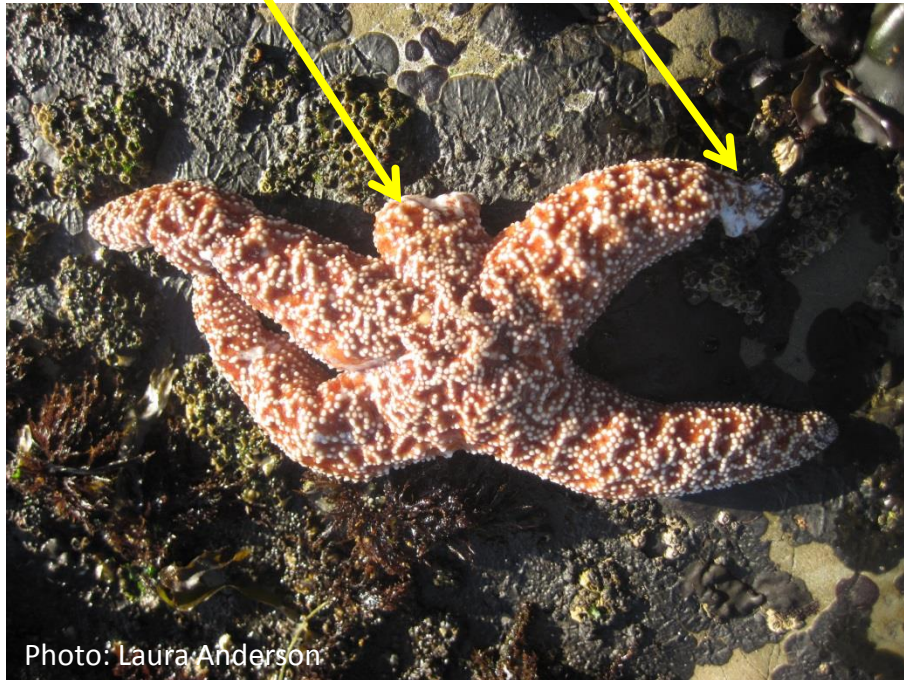Missing 1 arm

tissue deterioration on 2nd arm

Photo: Melissa Miner

Missing 1 arm

Photo: Laura Anderson

Photo: Nathaniel Fletcher

Severe (previously Category 3)

Photo: Angela Johnson

Photo: Elizabeth Seacord

Photo: Angela Johnson
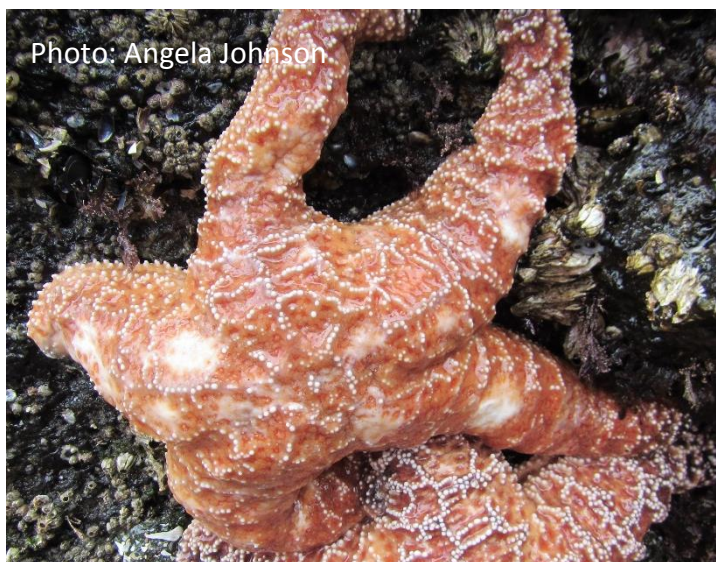
Missing tips of 2 arms, lesion on 3rd

Photo: Steve Fradkin

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Severe (previously Category 4)

severe tissue deterioration/death and/or ≥3 missing arms

Photo: Angela Johnson

Photo: Melissa Miner

Photo: Melissa Miner

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Internal organs emerging from lesions

Photo: Melissa Miner

Photo: Dennis Paulson

Photo: Melissa Miner

Spawning (all healthy/Category 0)

Spawning
(all healthy/Category 0)